CAPTIVE PROPAGATION OF BALD EAGLES AT PATUXENT WILDLIFE RESEARCH CENTER AND INTRODUCTIONS INTO THE WILD, 1976-80

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Abstract

One to 5 pairs of the Bald Eagle (*Haliaeetus leucocephalus*) were in the captive propagation project at Patuxent Wildlife Research Center during 1976–80. Four pairs produced viable eggs or young by natural mating in one or more years. Pairs laid second clutches 9 of 11 times when their first clutches were collected within 8 days of clutch completion. Sixty-nine percent of fertile artificially incubated eggs hatched; 93% of fertile parent-incubated eggs hatched. Eleven eaglets from artificially incubated eggs were hand reared. Age of birds at the time they were acquired from the wild was not a factor in their reproductive success.

Ten hand-reared and 2 parent-reared young were fostered to adult Bald Eagles at active wild nests; 11 were accepted and survived. Eleven parent-reared young were provided to hacking projects. Egg transplants to wild nests were conducted, but discontinued because of poor success. Double clutching of captive pairs has not resulted in substantially increased numbers of eaglets. Additional research is needed in artificial incubation, artificial insemination, and nutrition and care of hand-reared eaglets.

Introduction

Bald Eagles have been maintained in captivity, primarily in zoos, for many years but few attempts have been made to propagate them. The lack of interest in breeding this species in captivity probably relates to its infrequent use in falconry. Most captive propagation attempts before 1973 were summarized by Hancock (1973). Other successful propagation attempts have also been reported (Anonymous 1969, Wellenkamp 1973, Johnson and Gayden 1975, Maestrelli and Wiemeyer 1975, Minnemann 1976). These breeding attempts resulted in the production of less than 30 eaglets, most of which were produced at the Buffalo Zoo between 1910–16 (Annonymous 1909, Hancock 1973) and by a pair held by an individual in Toledo, Ohio in the 1880's (Hulce 1886, 1887).

The first successful captive breeding of Bald Eagles at Patuxent Wildlife Research Center, Laurel, Maryland was in 1973 when one pair produced two eaglets (Maestrelli and Wiemeyer 1975). This pair produced three young from a single clutch in 1974 and four young from two clutches in 1975, two by hand rearing and two by parent rearing (Wiemeyer, unpublished). The pair (male from Alaska; female from Alabama) was separated following the 1975 breeding season; new mates were of more similar geographic origin. Limited information on the reproductive behavior of this pair and one additional pair, both of which were present in 1973, was reported by Gerrard *et al.* (1979).

The purposes of this paper are to present information on procedures used and results obtained in propagating Bald Eagles at the Center, and in introducing eggs and eaglets into the wild for the years 1976–80. The primary purpose of this project was to pro-

duce eggs and eaglets for supplementing production in depressed wild populations and for reintroduction attempts where Bald Eagles have been extirpated. This breeding project was funded by the Environmental Contaminants Evaluation Program of the U.S. Fish and Wildlife Service. It was transferred to the Endangered Wildlife Research Program in October 1980.

Source of Birds and Age at Acquisition

The eagles were acquired from a number of sources (Table 1). Some individuals were obtained through zoos; their histories were often incomplete. Others that had been taken from the wild following sickness or injury were obtained from law enforcement authorities. All birds were capable of flying about in the breeding pens without difficulty.

Table 1. Source and age of Bald Eagles in the breeding project.

Pair	Date Paired	Sex[a]	Original State of Acquisition	Age When Acquired From Wild[b]	Age When Paired (years)[b]
A	17 Feb. 1976	M	Florida	Immature	6+
		F	Alabama	ca. 3 years	14
B	28 Feb. 1977	M	Alaska	large nestling	11
		F	Wisconsin	large nestling	11
C	28 Feb. 1977	M	Maine	Immature[c]	6+
		F	Minnesota	< 1	6
D	20 Oct. 1977	M	Florida	Nestling?	6
		F	Florida	Nestling or Immature	14
E	23 Jan. 1979	M	Alaska	≤ 3	12+
		F	Michigan	Adult	13+

[a] M = male, F = female.

[b] Some ages based on the time when adult plumage was first obtained in captivity, assuming that it is normally acquired at 4 years.

[c] Originally acquired November 1970. Released in Maryland in January 1973. Found shot and reacquired in Delaware in April 1975.

The age of some birds of prey at the time they are taken from the wild has been an important consideration in determining the probability that they will successfully breed in captivity. Falcons taken as large nestlings and raised with congeners have been productive breeders in captivity, whereas those taken as independent immatures or as adults have done poorly (Cade *et al.* 1977). Eagles in this project that were obtained as large nestlings, immature independent birds, and as adults have bred successfully. In another study, two Bald Eagles taken from the wild as adults laid eggs, incubated and hatched them, but lost both eaglets within 17 days of hatching (Barger 1963).

Sex Determination and Pairing

Most birds in the breeding project were sexed on the basis of past reproductive performance or by laparotomy. The male of pair E was sexed by cloacal examination. The method of sexing eagles with plasma steroid hormones previously used (Dieter 1973) was found to be unreliable.

A male and female of similar geographic origin were placed together to form each breeding pair and hereafter are referred to by letter (Table 1). When most pairs were formed alternate choices for mates were unavailable. The male was placed in the breed-

ing pen for several days to several weeks in advance of the female. This seemed to lessen early aggression initiated by the female.

On 7 December 1979 pair D was separated and removed from the pen. The male produced by pair A in 1976 was introduced into the pen on that date. The female was returned to the pen on 12 December. The male was rejected by the female and he was removed on 25 January 1980. Her original mate was returned on 28 January.

Facilities and Maintenance

The pen design (11 × 22 × 5.5 m high) used by our breeding pairs has been described (Maestrelli and Wiemeyer 1975). Four adjoining pens of this unit were used in one or more of the years 1976–78.

A new row of eight adjoining pens of the same design was constructed in 1978 in an area of the Center isolated from human disturbance. The exterior of the pens was covered with 2.5 × 5 cm mesh welded wire and the interior partitions were of 2.5 × 2.5 cm mesh welded wire. Placement of the nest platform, perches, shelter and feeding blocks was the same as in the older pens. A 3.7 × 3.7 m area of corrugated aluminum roofing was placed on the roof of each pen over the nest area. Wood sides, 34 cm high, were added to the nest platforms to help retain nest material. Nests were then filled with sticks, cattails, straw, and pine bark mulch.

Sticks and straw were placed on the ground of each pen for the adults to add to the nests. Fresh nesting material was placed in the nests each year. Grass and forbs covered the ground of the pens. Both nesting materials provided to the birds and naturally occurring materials were added to the nests by the birds. Woody vegetation and vines in the pens were controlled with herbicides and by mowing.

In 1979 and 1980 the new pens 1, 2, 3, 5 and 7 were occupied by Bald Eagle pairs. Pens 4 and 6 were occupied by single 4-year-old Bald Eagles and pen 8 was occupied by two immature Andean Condors (*Vultur gryphus*) in 1979. In 1980, pen 4 was empty and pens 6 and 8 were occupied by immature Andean Condors.

Eagles were fed 6 days a week during the non-breeding season and daily during the breeding season. The birds were fed through small wire feeding doors adjacent to each feeding block. The diet consisted of laboratory rats, fish (mostly brackish and saltwater varieties), and 3- to 5-week old chickens. Fish and rats were usually fed three times each week. When chickens were available (primarily before and during the breeding seasons) they were fed one or two times a week in place of other items. Hamsters were occasionally substituted for rats and Coturnix quail for chickens. Rodents and fowl were obtained alive, killed with CO_2 and frozen. Fresh fish were obtained and then frozen. Food was thawed as needed. One or more items were placed on each of the two feeding blocks in each pen to avoid conflicts over single items. Leftover food items within reach of feeding doors were removed daily. Items out of reach of feeding doors were removed less frequently. Most birds were very defensive during the breeding season, discouraging entry into the pens for removal of leftover items. A few birds made entry difficult throughout the year.

Water was provided in a stainless steel pan. Pans were placed just inside the door of each pen to facilitate removal for cleaning. Pans were cleaned and refilled once or twice a week as needed. The birds frequently bathed in the pans, especially following cleaning. Drinking was observed very infrequently. There was no electrical service to the new pens, therefore the pans were unheated. Water was periodically provided in winter, but rapidly froze during cold weather.

The birds were observed with a 30x spotting scope from an elevated blind approximately 120 m from the older pens and 67 m from the newer pens. Observations were not conducted on a regular basis and periods seldom exceeded one hour, except in 1980. A mirror over each nest facilitated observations of nest contents from a point immediately in front of each pen. The mirrors were placed so that birds were unlikely to see their reflection. A few birds were observed looking at the mirrors and one bird was seen to briefly attack one mirror on two occasions.

Copulation

Most copulations that were observed occurred from 6 days before to 3 days following the laying of the first egg of the first clutch. The earliest copulation that was observed occurred 37 days before the laying of the first egg of a first clutch. Three pairs were seen copulating following collection of a first clutch. Most instances occurred before or during the laying of a second clutch. For example, in 1978, copulation by pair B was observed three times (3.2 h of observations) 1 day before the laying of the first egg of the second clutch and once on the day of laying, but before the egg was laid. Copulation by this pair was also observed 4 days following the collection of the second clutch in 1979, after it failed to hatch. Pairs C and E were each seen copulating three or more times following the collection of their first clutches in 1980; neither laid a second clutch. Copulation normally occurred at one of the nest perches; pairs A and E were observed copulating on the ground on several occasions.

Artificial Insemination

In 1980, semen collections were made from three males that were not paired. A modified massage technique described by Gee and Temple (1978) was used. Males were netted and then restrained in a standing position with their feet on a log perch. One assistant held the legs of the bird and a second held the wings against its body; both assistants faced the rear of the bird. The operator then stroked the bird and manipulated the cloaca. Occasionally ejaculation occurred. Semen was collected from the ventral lip of the cloaca on the lip of a plugged glass funnel or with a propipette attached to a small pipette. The process from stimulation by the operator to collection of the semen was usually accomplished in less than 30 seconds.

On 14 March 1980 semen was collected from the male produced by pair A in 1976 and from a crippled southern male. The semen was pooled. The female of pair D was netted, restrained, and the semen deposited into her cloaca, within an hour of collection. Insemination into the oviduct would have been better than into the cloaca, but she was difficult to restrain. She laid the first egg of a second clutch of two eggs (see below) on 21 March. Both eggs failed to hatch and appeared infertile when examined. Repeated inseminations would have been preferable, but were not conducted because of the risk of excessive disturbance to breeding birds in nearby pens during capture of the female.

Laying, Incubation and Hatching

Dates of laying of the first egg of the first clutch for each pair are given in Table 2. The initiation of laying may have been delayed in some cases by late dates of pair formation (Table 1) or late return of pairs to their pens following repairs and rebuilding of nests (early to mid-February in 1976–78). The initiation of egg laying by the female of pair C in 1977 and 1978 also may have been delayed as the result of reproductive activities of pairs in adjacent pens.

The time of day of egg laying was noted on two occasions; both occurred between 1530 and 1640. Eggs were laid at a minimum of 2 day intervals. Incubation nearly always began with the laying of the first egg. Many pairs did not stop incubating in the presence of caretakers, making it impossible to determine laying dates of subsequent eggs. The female of pair B laid the first egg of a fertile two egg clutch only 16 days following pair formation in 1977.

Table 2. Dates of laying of the first egg of the first clutch for females of captive Bald Eagle pairs.[a]

	Year				
Pair	1976	1977	1978	1979	1980
A	23 March	14 March	6 March	2 March	28 February
B	(22 March)[b]	16 March	27 February	20 February	3 March
C	(6 March)	17 April	4 April	12 February	2 February
D			27 January	29 January	15 February
E			(20 March)	26 March	21 February

[a] Initiation of egg laying was delayed by dates of pairing and pen maintenance in some years (see text). Some dates approximate.

[b] Dates in parentheses are for years when the females were not paired.

First clutches were collected for artificial incubation (Table 3) from 3 pairs in 1978 and 4 pairs each in 1979 and 1980, approximately 5 to 8 days following clutch completion. Each pair laid a second clutch with two exceptions in 1980 (Table 3). Both members of each pair were normally caught and restrained before the collection of their eggs to prevent attacks upon collectors. Eggs to be artificially incubated were left with the pairs for several days of natural incubation following clutch completion because this has been found to increase the hatchability of wild birds' eggs that were to be artificially incubated (Cade *et al.* 1977). If collection of first clutch eggs is delayed too long the pairs may not relay. No second clutch was laid by pair A in 1977 following collection of the first clutch about 13 to 16 days following clutch completion. The inter-clutch interval (time from collection of the first clutch to laying of the first egg of second clutch) ranged from 18 to 23 days. This interval was similar to the interval between pairing and laying of two pairs (16 days for pair B in 1977 and 18 days for pair D in 1980).

Eggs to be artificially incubated were placed in Petersime Model 5 incubators at 37.6°C dry bulb and 30°C wet bulb (about 56% relative humidity), and turned automatically every 2 h. (Use of brand names does not imply endorsement by the Federal government.) Eggs were placed on their sides in trays used for duck eggs as modified to hold eagle eggs. It might have been better to place them large end up, but space restrictions between trays prevented this. No eggs were available to experiment with various temperatures and humidities of artificial incubation, therefore those used may not be optimal.

Eggs were placed in the hatching compartment of the incubator when they pipped, and the relative humidity was increased to about 70%, although a higher humidity might have been preferable. Eggs were placed on their sides with pips uppermost. Hatching occurred from 24 to 48 h after pipping. Some eaglets were very carefully helped from the shell if they appeared to not be making any appreciable progress 30 h after pipping. One eaglet in 1979 pipped and hatched, with help, from the apex end of

the egg. The eaglet had an external yolk sac (see below). Eaglets were heard vocalizing within the shell at least 12 h before pipping on several occasions.

Twenty-one fertile Bald Eagle eggs were artificially incubated in 1978–80 (Table 3). Three of them were transplanted to nests in the wild and one was given to another captive pair. One egg from pair B in 1980 was buried in the nest lining and was cold when collected. Eleven of 16 remaining eggs (69%) hatched.

For the years 1976–80, 34 Bald Eagle eggs were parent incubated (Table 3). Fertility of parent-incubated eggs was determined by examining their contents after they failed to hatch. Small embryos may have gone undetected. The fertility of three eggs that were transplanted to wild nests was not determined. Fifteen of the remaining 31 eggs were fertile and 14 hatched (93%). The only fertile parent-incubated egg that failed to hatch was not incubated to full term by pair C in 1979, possibly because of interference by a wild adult Bald Eagle at the pens at about the time incubation ceased (Table 3). For those parent-incubated clutches containing at least one fertile egg, 74% of the eggs laid hatched. All pairs incubated their eggs; both members of each pair participated

Table 3. Reproduction by pairs of captive Bald Eagles.

Pair	Year	Clutch	No. Eggs			Young
			Laid[a]	Fertile	Hatch	Raised[b]
A	1976	1	3(P)	1	1	1(P)
	1977	1[c]	3(P)[d]	(1)	—	—
	1978	1[c]	3(A)	3	—	—
		2	2(P)	2	2	2(P)
	1979	1	3(A)	3	3	3(H)
		2	2(P)	2	2	2(P)
	1980	1	3(P)	2	2	2(P)
B	1977	1	2(P)	2	2	2(P)
	1978	1	3(A)	3[e]	1	1(H)
		2	2(P)	2	2	2(P)
	1979	1	2(A)	2	2	2(H)
		2	2(P)	0	0	0
	1980	1	2(A)	2	1	1(H)
		2	2(P)	1	1	1(P)
C	1977	1	2(P)	0	0	0
	1978	1	2(P)	2	2	2(P)
	1979	1	3(A)	3	3	3(H)
		2	1(P)	1	0	0
	1980	1	3(A)	3	0	0
D	1978	1	2(A)[f]	0	0	0
		2	2(P)	0	0	0
	1979	1	2(A)	0	0	0
		2	2(P)	0	0	0
	1980	1	3(A)	0	0	0
		2	2(P)	0	0	0
E	1979	1	2(P)	0	0	0
	1980	1	2(A)	2	1	1(H)

[a] P = Parent-incubated; A = artificially incubated.
[b] P = Parent-reared; H = hand-reared.
[c] Eggs transplanted into wild nests.
[d] Eggs not candled; one hatched in wild nest.
[e] One egg given to pair D after their eggs failed to hatch; they failed to hatch this egg.
[f] One broken.

(Gerrard *et al.* 1979). Both sexes have brood patches. The incubating pairs were quite defensive of humans and of eagles in adjoining pens that approached the partitions.

The major cause of infertility appeared to be lack of copulation. One pair (D) produced six clutches of infertile eggs. The first clutch produced by each of two pairs (C and E) in the first year they were paired (1977 and 1979) were also infertile. In each case copulation was not observed before or during laying of the first clutch. The above factors accounted for 74% of all infertile eggs produced. Additional pairs were not seen copulating before or during the laying of their first clutches (A in 1976, B in 1977 and 1980, C in 1978 and 1980), but each produced one or more fertile eggs in these clutches.

Average clutch size was 2.5 eggs in first clutches and 1.9 eggs in second clutches. One female (A) consistently laid three eggs in each of five first clutches.

Bacteriological cultures were attempted from four fertile eggs that failed to hatch under artificial incubation in 1980. All cultures using as many as six media were negative, including tests for *Salmonella*. Two of these eggs were cultured for adenoviruses; these attempts were negative.

Eaglet Care

One case of an unretracted yolk-sac was observed in 1979. The sac was ligated at the sphincter; an antibiotic salve was applied to the umbilicus area and the sac was allowed to drop off. It might be preferable to cut the sac off immediately following ligation. The eaglet survived.

The eaglets were removed from the hatcher after they had dried. They were then placed in a thermostatically controlled forced air incubator-brooder and the temperature was initially maintained at about 36°C and the relative humidity at about 50%. The temperature was gradually lowered about 0.5°C per day. In 1979 and 1980, when the eaglets were about 1 week old, they were moved to a larger thermostatically controlled brooder. There was no control of humidity in these, however a room humidifier was used to help maintain humidity. When the eaglets were about 3 weeks old and were able to thermoregulate at room temperature, they were placed in large boxes and maintained at room temperature (about 22°C). Correct temperature was determined by observation of the eaglets' behavior. They panted when too hot, chittered and shivered when too cold, and slept quietly when comfortable.

The eaglets were kept in low boxes within the brooders and later inside the large boxes in the room. The inner boxes restricted the movement of the eaglets so that they could not readily come in contact with their feces. Inner boxes, which were slightly larger than the eaglets, were lined with absorbent paper backed with plastic, and with fumigated straw. The birds were kept in depressions in the straw when small, to prevent spraddling of their legs. Brooder liners, boxes and bedding material were changed as needed. Eaglets were raised with their siblings in 1979, usually within the same inner box. If one became excessively aggressive they were kept in separate inner boxes, but in sight of one another.

The eaglets were first fed within 24 h of hatching. They were given small pieces of food with blunt forceps. In 1979 and 1980, the diet consisted of one-half to two-thirds fowl (Coturnix quail, chickens, or ducks) and the remainder fish. The muscle, heart, and liver of fowl and scaled and filleted fish were used. Fish liver was occasionally incorporated into the diet. The items were cut into pieces appropriate to the size of the eaglets. The diet was supplemented with Polyvisol (liquid infant vitamins) at 1–2 drops per 10 g of food. After the eaglets were a few days old, calcium carbonate was added to

make up 1 to 1.5% of the diet. Vionate (a vitamin-mineral supplement) was gradually incorporated into the diet when the eaglets were about 1 week old and constituted less than 1% of the diet. When the eaglets were about 3 weeks old the fish were no longer scaled. The food was wet with water before feeding to help the eaglets in swallowing it and to insure that they did not become dehydrated. Food types were mixed at each feeding. Eaglet weights were recorded daily. The amount and types of food were recorded at each feeding. These records were useful in monitoring the health of the birds. Some eaglets began to avoid hand feeding when 5 to 6 weeks old, especially if they were frequently handled.

The eaglets were fed about every 3 h during daylight for the first few days. The frequency of feeding declined to four or five feedings per day at 3 weeks of age. The birds were often fed until gorged in 1979. This was avoided in 1980 by visual inspection and palpation of the esophageal area, as excess food may spoil in the digestive tract and result in poisoning (Cade *et al.* 1977). Feedings in 1980 were normally given on empty or near empty crops.

One eaglet from pair C in 1979 developed a 90° lateral rotation of the tibia. The cause was unknown. All efforts to correct the rotation failed and the eaglet was euthanized.

The hand-reared eaglet from pair E in 1980 developed crooked toes on both feet that curled laterally when about 8 days old. After several initial unsuccessful attempts to straighten the toes, we taped a piece of heavy cardboard the size of the eaglet's foot to the end of a tongue depressor cut to the length and width of the eaglet's tarsus. The eaglet's tarsi were wrapped with cotton and the above devices taped around each tarsus. The toes were placed inside short slit-open pieces of plastic tubing, the interior diameters of which were about the same size as the respective toes. The tubing was aligned on the cardboard so that the toes were straight and then taped to the cardboard. The devices were changed every 1–2 days and adjustments to the components made in response to the growth of the eaglet. The toes were virtually straightened when the eaglet was 25 days old, 1 day before it was sent to New York. When the eaglet was examined 3 weeks later it appeared normal; the toes were still straight, but the middle toe of one foot seemed weak (P. E. Nye, pers. comm.). The cause of the original abnormality is unknown.

The parent eagles with young were provided extra food items so that sufficient food was always present for them to feed their young. Food was often provided to them twice a day so that a fresh item was available more frequently. When the eaglets were less than 1 week old a saliva-like fluid was seen dripping from the tip of the upper mandible of the adult feeding the young, thereby providing extra moisture and possibly digestive enzymes to the young with the pieces of food. This has also been observed for the White-tailed Sea Eagle (*Haliaeetus albicilla*) (Fentzloff 1978). A female Golden Eagle (*Aquila chrysaetos*) fed pieces of food to a small chick that she had partially swallowed (Hamerstrom 1970). The adult females provided the great majority of food to the eaglets in comparison to the males. The parent eagles successfully reared all of the young hatched by them to 3 to 9 weeks of age at which time the eaglets were needed for transplant to wild nests or for hacking.

Egg Transplants

Eggs to be transplanted to wild nests, including eggs that were collected during transplant operations and during some eaglet introductions, were placed in an oversized at-

tache case (45 × 32 × 17 cm). The case was lined with styrofoam. Eggs were placed in depressions cut in the styrofoam. The temperature in the case was maintained with hot water in two hot water bottles that laid on a sheet of styrofoam separating them from the eggs. Holes in the styrofoam sheet allowed passage of heated air. The sheet prevented contact between the eggs and the killing temperature of the hot water bottles. Temperature in the case near the eggs was monitored with a dial thermometer that was inserted through a small hole in the case near the handle with the dial on the exterior. The temperature was maintained within a range of 32–37°C for up to 4 h, providing the case was not opened, without changing the water in the bottles. Cases of similar design have been used to transport bird eggs of several species (Erickson 1981).

Captive-produced Bald Eagle eggs were transplanted into active nests in the Chesapeake Bay region in both 1977 and 1978 (Table 4). The recipient nests had histories of reproductive failure for several years or high levels of contaminants in eggs produced in the previous year. Three eggs from pair A were used in transplants each year. The eggs transplanted in 1977 had been incubated by the captive pair for 2 to 3 weeks when collected; it was not known if all eggs were fertile or viable. Those transplanted in 1978 were in the fourth week of incubation, 3 weeks of which were under artificial incubation; all were fertile and appeared viable.

Only one introduced egg was known to hatch; the eaglet survived and fledged (Table 4). Four of five of the remaining eggs failed to hatch, presumably because of nest abandonment (Mason Neck 1978) and chilling of the eggs from delays in the resumption of incubation by the wild birds. The cause of failure to hatch of the fifth egg (Mason Neck 1977) was unknown.

Four of the six wild-produced eggs removed from nests during egg transplant operations were non-viable. One hatched under artificial incubation, but the eaglet died. The remaining egg was thought to have been non-viable because of a floating air cell (probably caused by a handling mishap), but appeared viable when opened.

Table 4. Transplants of captive-produced Bald Eagle eggs into wild nests.

Recipient Site	Wild-produced Eggs		Captive Eggs Introduced	Eggs Hatched in Wild Nests
	Present	Removed		
	1977			
Mason Neck, VA	1	1[a]	2	1
Holly Forks, VA	2	2[b]	1	0
	1978			
Mason Neck, VA	1	1[c]	2	0
Bombay Hook, DL	3	2[a]	1	0

[a] Eggs non-viable; failed to hatch under artificial incubation. All contained high levels of environmental contaminants.

[b] One non-viable egg cracked and one viable egg probably damaged (floating air cell) as a result of a handling mishap at the nest.

[c] Egg hatched under artificial incubation. Eaglet died of chronic bronchio-pneumonia when 33 days old. It also had secondary osteomalacia, possibly as a result of changes made in its diet in an effort to keep it eating during its long (18 day) illness.

Eaglet Introductions into Wild Nests

Ten hand-reared and two parent-reared captive-produced eaglets were fostered to wild adults in active nests, usually with long histories of reproductive failure, when they were 2.5 to 6 weeks old during the years 1978–80 (Table 5), Eaglets younger than 2.5 weeks may not be able to thermoregulate for extended periods while awaiting care by wild adults, and thus may become excessively chilled. Hand-reared eaglets in excess of 6 weeks may not have enough time to overcome imprinting on humans before fledging

Table 5. Fostering of captive-produced Bald Eaglets to adults at wild nests 1978–80.

Recipient Site	Nest Contents		Nest Contents	Captive Young		Captive Source	Disposition of Nest Contents Removed
	Eggs	Young	Removed[a]	Introduced[b]	Fledged	Pair	
				1978			
Bonum Cr., VA	0	1	1Y	2(P)	2	A	Eaglet moved to Jones Pond, VA nest; placed alongside young of similar size. Both fledged.
Hemlock L., NY	1	0	1E	1(H)	1	B	Egg non-viable.
				1979			
Dahlgren, VA	0	1	1Y	2(H)	2	A	Eaglet moved to Chantilly, VA nest; placed alongside young of similar size. Both fledged.
Coles Neck, VA	0	1[c]	0	1(H)	1	A	—
Hemlock L., NY	0	0	—	2(H)[d]	—	B	—
Pymatuning L., PA	(2)	0	(2E)	1(H)	1	B	Goose eggs had been placed in the nest to maintain incubation; discarded.
Brandy Pond, ME	2	0	2E	1(H)	0[e]	B	One egg non-viable. The other was thought to have been non-viable when candled, but appeared to have been viable when opened later.
Swan Is., ME	2	0	2E	1(H)	1	C	Both eggs hatched under artificial incubation. One eaglet died. The other eaglet was hand-reared and placed in a nest near Steuben, ME alongside a wild-produced young of similar size. Both fledged.

(Cont. on next page)

Table 5 (cont.)

Machias, ME	1	0	1E	1(H)	1	C	Egg hatched under artificial incubation. Eaglet hand-reared and placed in nest near Passadumkeag, ME alongside a young of similar size. Both fledged.
				1980			
Ottawa, OH	0	1[c]	0	1(H)	1	B	—
Hemlock L., NY	(1)	0	(1E)	1(H)	1	E	Dummy egg in nest removed.

[a] Y = young; E = egg.
[b] P = parent-reared; H = hand-reared.
[c] Eaglet left in nest with introduced young; both fledged.
[d] Eaglets not accepted by wild pair. The pair had been seen in incubation posture in the nest, but the nest was found to be empty when eaglets were introduced. The eaglets were later removed and introduced into nests elsewhere.
[e] Eaglet killed by wild adult.

from wild nests. Three kinds of nests were used: those with eggs (including goose eggs and dummy eggs placed in empty nests to maintain incubation), with wild-produced young of similar size (which were left in the nest), and in place of wild-produced young of different size, which were in turn moved to other wild nests with young of their size. Eaglets were transported in cardboard cartons or wood crates (that were lined with clean straw as bedding material) by auto, single engine government aircraft and commercial aircraft. Eleven of 12 fostered eaglets were accepted by wild adult eagles, and were either seen in advanced stages of development in nests or were known to have fledged. All wild-produced eaglets in manipulated nests were also seen in advanced stages of development and presumably fledged. Captive-produced White-tailed Sea Eagles have also been fostered to wild adults (Fentzloff 1978).

One 5-week-old eaglet introduced into a nest at Brandy Pond, Maine (Table 5) was killed by a wild adult eagle. It had been introduced into the nest in place of two eggs and was standing in the nest when the wild adult returned and landed on a limb about 2.5 m from the nest 10 minutes after the climbing crew left the tree. The eaglet spread and flapped its wings. The adult immediately left the limb, flew off, circled, came back to the nest in a stoop with outstretched talons and killed the eaglet, knocking it out of the nest (R. B. Owen, Jr., pers. comm.). The adult presumably mistook the eaglet for a predator or intruding eagle.

A second hand-reared eaglet of similar age, even though hungry, refused food from its caretakers before being placed in the Machias, Maine nest (Table 5). It begged for food from a wild adult upon the adult's arrival at the nest, even though it had never before seen an adult eagle.

Eaglet introductions in the Maine nests in 1979 (Table 5) were all conducted in territories with long histories of reproductive failure. Three of five eggs removed from the three nests hatched under artificial incubation. Two eaglets survived hand rearing; the third, very small at hatching, died. The two surviving eaglets were introduced into Maine nests alongside wild-produced young of similar size. All were seen in advanced stages of development and presumably fledged.

Captive-Produced Young Sent to Hacking Projects

Eleven captive-produced parent-reared young 7 to 9 weeks old were provided to hacking projects between 1977–80 (Table 6). Seven young were provided to New York and were hacked successfully to the wild at Montezuma National Wildlife Refuge (P. Nye, pers. comm.) where Bald Eagle hacking procedures were first developed by Milburn (1979). Four young were provided to the Georgia Department of Natural Resources; they were hacked successfully to the wild at Sapelo Island, Georgia (R. Odum, pers. comm.). Hacking has also been used in the reintroduction of White-tailed Sea Eagles in Scotland (Love and Ball 1979).

Table 6. Captive-produced Bald Eagles provided to hacking projects.

Hacking Project	Year			
	1977	1978	1979	1980
New York	2(B)[a]	4(B,C)	—	1(B)
Georgia	—	—	2(A)	2(A)

[a] Source pairs given in parentheses.

Discussion and Conclusions

Considerable progress has been made in the captive propagation of Bald Eagles in the last 10 years. Current knowledge and effort have made possible the production of modest numbers of eaglets for reintroduction attempts and supplementing production of depressed populations. Information and experience gained during these years has been helpful in assessing the value and potential of various techniques.

Bald Eagle egg transplants should not be considered as a productive method of supplementing the production of depressed populations. Major problems encountered in the use of this technique in this study were the outright abandonment of introduced eggs and excessive delays in the resumption of incubation following transplants. These problems were also encountered in transplants of wild-produced Bald Eagle eggs from the Great Lakes states to Maine in 1974–76 (F. Gramlich, C. Madsen and P. Nickerson, pers. comms.). These problems might have been lessened in a few isolated cases in these studies by reductions in time spent at recipient nests by egg introduction teams. The strong desire to determine if and when a wild pair returns to its nest following an egg transplant may be counter-productive in some cases. An observer even at a distant observation site might cause a delay in the resumption of incubation, resulting in chilling of eggs and death of embryos. Perhaps efforts to obtain such information should be abandoned. An aerial check of the nest 1 h following an egg transplant could provide information on acceptance or abandonment of eggs. Even with these modifications egg transplants should be considered only when other techniques cannot be used. The placement of goose eggs or dummy eggs in nests shortly following the loss of wild-produced eggs or in the nest of a pseudo-incubating non-laying pair can hold pairs on their nests until eaglets become available for introductions, as occurred in Pennsylvania in 1979 and New York in 1980.

Double clutching of captive pairs at this Center has not resulted in substantially increased numbers of eaglets. If all 16 fertile eggs that were artificially incubated to termination (see above) had been left with the parents (no double clutching) and all had hatched and eaglets survived (similar to actual success for parent-incubated fertile eggs), the production would have been the same as that actually observed from these pairs

with double clutching. Modest improvements in hatchability of artificially incubated eggs and consistent laying of and production from second clutches are needed before double clutching will result in increased production. The time and expense of hand rearing first clutch young must be balanced with the need for increased production, with the manager making appropriate decisions with regard to available resources and the value placed on the birds. Double clutching could be reserved for unpaired females that are to be artificially inseminated or individual pairs that fail to incubate their own eggs or rear their own young. It could also prove beneficial with specific pairs that consistently produce viable first clutch eggs and young from second clutches, especially if modest improvements in hatchability of artificially incubated eggs are realized.

Knowledge of proper nutrition and care of hand-reared young has not been perfected, as suggested by the occasional appearance of skeletal abnormalities. No abnormalities of these types have been seen in parent-reared eaglets. Eaglets should not be hand-reared for more than 5 weeks because of problems in the acceptance of food from caretakers. If eaglets must be hand-reared for longer periods they should be allowed to pick up pieces of food on their own. Hand-reared young should not be used in hacking projects because they most likely will become imprinted on humans.

Very little work has been done with artificial insemination of bald eagles. Artificial insemination techniques with Golden Eagles were previously described (Hamerstrom 1970, Grier 1973). The technique should prove valuable when working with females that are imprinted on humans and with unpaired egg-laying females. Forced semen collections did not prove to be difficult in very limited attempts. Methods of preserving eagle semen for later use could be explored.

Modest to major contributions to Bald Eagle production have resulted from the fostering and hacking of captive-produced eaglets into the wild. In New York, 7 of 22 Bald Eagles successfully hacked to the wild in the years 1976–80 were produced at this Center, whereas fostering of eaglets into a wild nest accounted for all and one-half of the total production from wild nests in the state in 1978 and 1980 (P. Nye, pers. comm.). In Georgia, no young were produced by wild eagles during 1979 and 1980 when four captive-produced eaglets were hacked to the wild (R. Odum, pers. comm.). The fostering of one eaglet in Ohio in 1980 accounted for 25% of the total production of Bald Eagles for the state (D. Case, pers. comm.). In Pennsylvania in 1979, the fostering of one eaglet accounted for all of the production in the state (M. Puglisi, pers. comm.). Fostering of captive-produced young in Virginia in 1978 and 1979 accounted for 10 and 13% of the total eaglet production (Dittrick and Clark 1978, Pramstaller and Clark 1979) whereas in Maine in 1979 it accounted for only 5% of total eaglet production (F. Gramlich, pers. comm.).

The ultimate success of any captive breeding program with release of progeny occurs when released birds successfully reproduce in the wild. Two wild-produced bald eagles that were hacked to the wild in New York in 1976 paired and produced young in 1980 (P. Nye, pers. comm.). The earliest that this could occur for this program would be in 1981 when those young released in 1977 could first reach sexual maturity, assuming survival. Larger numbers of released young should first become sexually mature in 1982 and 1983. It may be difficult to locate released birds at maturity because only those released at hacking projects carried adequate color markers for individual identification. There are few breeding birds in the hacking areas (New York and Georgia) thereby making easier the detection of new breeding pairs.

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Literature Cited

Anonymous. 1909. Wild birds bred in captivity in the Eastern United States. *Zoological Society Bull.* 36:580–583.

Anonymous. 1969. American Bald Eagle. *Zoonooz* 42:13.

Barger, B. A. 1963. Bald Eagles hatched in captivity. *Passenger Pigeon* 25:24–25.

Cade, T. J., J. D. Weaver, J. B. Platt and W. A. Burnham. 1977. The propagation of large falcons in captivity. *Raptor Research* 11:28–48.

Dieter, M. P. 1973. Sex determination of eagles, owls, and herons by analyzing plasma steroid hormones. U.S. Bureau of Sport Fisheries and Wildlife. Special Scientific Report—Wildlife No. 167. Washington, D.C.

Dittrick, B., and W. S. Clark. 1978. Chesapeake Bay Bald Eagle banding project report 1978. National Wildlife Federation, Raptor Information Center, Washington, D.C.

Erickson, R. C. 1981. Transport case for incubated eggs. *Wildl. Soc. Bull.* 9(1):57–60.

Fentzloff, C. 1978. The breeding and release of the White-tailed Sea Eagle (*Haliaeetus albicilla*) as performed by the Deutsche Greifenwarte Burg Guttenberg. Pages 97–103 in T. G. Geer, ed., *Bird of Prey Management Techniques*. British Falconers Club.

Gee, G. F., and S. A. Temple. 1978. Artificial insemination for breeding non-domestic birds. *Symp. Zool. Soc. Lond.* 43:51–72.

Gerrard, P. N., S. N. Wiemeyer and J. M. Gerrard. 1979. Some observations on the behavior of captive Bald Eagles before and during incubation. *Raptor Research* 13:57–64.

Grier, J. W. 1973. Techniques and results of artificial insemination with Golden Eagles. *Raptor Research* 7(1):1–12.

Hamerstrom, F. 1970. *An eagle to the sky*. Iowa State University Press, Ames. 142 pp.

Hancock, D. 1973. Captive propagation of Bald Eagles *Haliaeetus leucocephalus*—a review. *International Zoo Yearbook* 13:244–249.
Hulce, H. 1886. Eagles breeding in captivity. *Forest and Stream* 27:327.
Hulce, H. 1887. Eagles breeding in captivity. *Forest and Stream* 28:392.
Johnson, M. J., and R. Gayden. 1975. Breeding the Bald Eagle *Haliaeetus leucocephalus* at the National Zoological Park, Washington. *International Zoo Yearbook* 15:98–100.
Love, J. A., and M. E. Ball. 1979. White-tailed Sea Eagle *Haliaeetus albicilla* reintroduction to the Isle of Rhum, Scotland, 1975–1977. *Biol. Conserv.* 16:23–30.
Maestrelli, J. R., and S. N. Wiemeyer. 1975. Breeding Bald Eagles in captivity. *Wilson Bull.* 87:45–53.
Milburn, E. H. 1979. An evaluation of the hacking technique for establishing Bald Eagles (*Haliaeetus leucocephalus*). Master of Science Thesis, Cornell University. 184 pp.
Minnemann, D. 1976. Aufzucht eines Weisskopfseeadlers (*Haliaeetus leucocephalus*) durch ein Adlerbussardpaar (*Buteo rufinus*). *Zool. Garten* 46:54–65.
Pramstaller, M. E., and W. S. Clark. 1979. Chesapeake Bay Bald Eagle banding project report 1979. National Wildlife Federation, Raptor Information Center, Washington, D.C.
Wellenkamp, J. 1973. A first—in baby bald eaglets. *Southern Living* 8:36–38.

ARTIFICIAL BURROWS PROVIDE NEW INSIGHT INTO BURROWING OWL NESTING BIOLOGY

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Introduction

The breeding biology of Burrowing Owls (*Athene cunicularia*) is poorly understood, primarily because of the difficulty of studying an underground nesting species. Before the use of artificial burrows (Collins and Landry 1977), few attempts were made to intensively study Burrowing Owl nesting because of the nest destruction problem. Twenty artificial burrows, similar to those used by Collins and Landry (1977), were installed in eastern Oregon (Umatilla and Morrow counties) in the spring and summer of 1979; however, sandy soil and wind erosion resulted in only 12 burrows being relocated in 1980. In 1979 and 1980, we made observations on four nesting attempts by Burrowing Owls using these burrows. Our objective was to collect additional information on the breeding biology of this species. The points made in this paper all come under the basic heading "know the species" which is essential before attempting to develop a *census* procedure, or even a method for evaluating *productivity* of a species.

Results

The observations recorded during this study are presented separately for each burrow, although the food habits information is pooled.